

***SUPER-PUMA  
Mk1 & Mk2***

***NH90***

***SUPER-PUMA MK2+  
EC225 / 725***

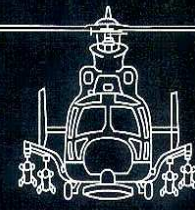
***EC155***



# **ICE PROTECTION of HELICOPTERS at EUROCOPTER**

***Bernard TAGLIANA , design office***

***FAA & SAE In-flight icing / ground deicing international conference - Chicago, II- June 16-20, 2003***



***SUPER-PUMA  
Mk1 & Mk2***

***NH90***

***SUPER-PUMA MK2+  
EC225 / 725***

***EC155***

- ☐ **past certifications & experience**
- ☐ **general items about R/C with IPS in development**
- ☐ **icing envelopes**
- ☐ **design & protections**
- ☐ **qualification process**
- ☐ **icing tests : wind tunnel & flights**
- ☐ **planning of development / qualification**
- ☐ **w.g. & research activities**
- ☐ **conclusion**



# SUPER-PUMA: ICING CERTIFICATIONS



AS 332 MK1 & MK2

❑ AS 332 MK1 is CERTIFIED for FULL ICING conditions (FAR 29, app. C) :

✉ DGAC : 1983

✉ FAA : 1984

(kit with protection of airfoils)

❑ CAA certificates for LIMITED ICING conditions :

✉ AS 332 MK1 : 1983

✉ AS 332 MK2 : 1993

(Z-p < 8000 feet , OAT > -10°C)  
(kit without protection of airfoils)



# **SUPER-PUMA: EXPERIENCE**



## **□ Global experience of SUPER-PUMA MK1 :**

**✉ around 20 YEARS of CIVIL IN-SERVICE  
EXPERIENCE**

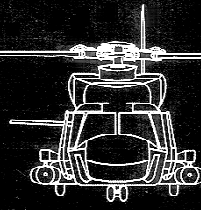
**✉ 120 AS 332 MK1 with IPS (300000 F.H.) ->  
around 15 000 F.H. in icing cond.**

## **□ Conclusion :**

**✉ Ice Protection System of MK1 is efficient**



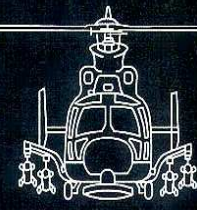
***SUPER-PUMA  
Mk1 & Mk2***



***NH90***



***SUPER-PUMA MK2+  
EC225 / 725***



***EC155***

## **CURRENT SITUATION**

- ❑ 3 simultaneous developments of IPS on R/C
- ❑ goal :
  - ✉ wider range of helicopters with increased capability to operate in bad weather conditions, particularly ICING , for both safety / mission



# **SUPER-PUMA Mk2+ EC 225 / 725**



**an extended version of SUPER-PUMA MK2**

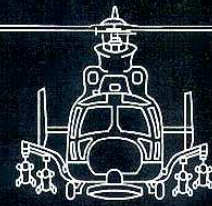
- ❑ MAIN ROTOR :
  - ✉ 5 NEW BLADES
- ❑ TAIL ROTOR: Mk2
- ❑ NEW ENGINE: ARRIEL 2C2
- ❑ HORIZ. STABILIZER: Mk1







# DOLPHIN - EC 155



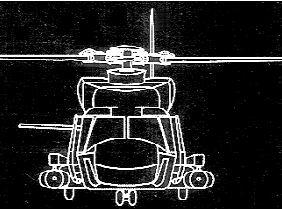
## DOLPHIN family - MEDIUM RANGE R/C

- ❑ MAIN ROTOR : 5 NEW BLADES
- ❑ « FENESTRON » TAIL ROTOR





# NH90



**FRANCE**



**ITALY**



**GERMANY**



**NETHERLANDS**



**PORTUGAL**



**export :**

**FINLAND**



**NORWAY**



**SWEDEN**



**EUROCOPTER AGUSTA**  
PARTNER COMPANIES

**EUROCOPTER  
DEUTSCHLAND**

**FOKKER**

**PORTUGUESE IND.**  
PARTNER COMPANIE'S  
SUBCONTRACTOR



**a Tactical Transport  
Helicopter "TTH"**

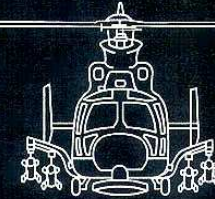


**a Naval Multirole  
Helicopter "NFH"**



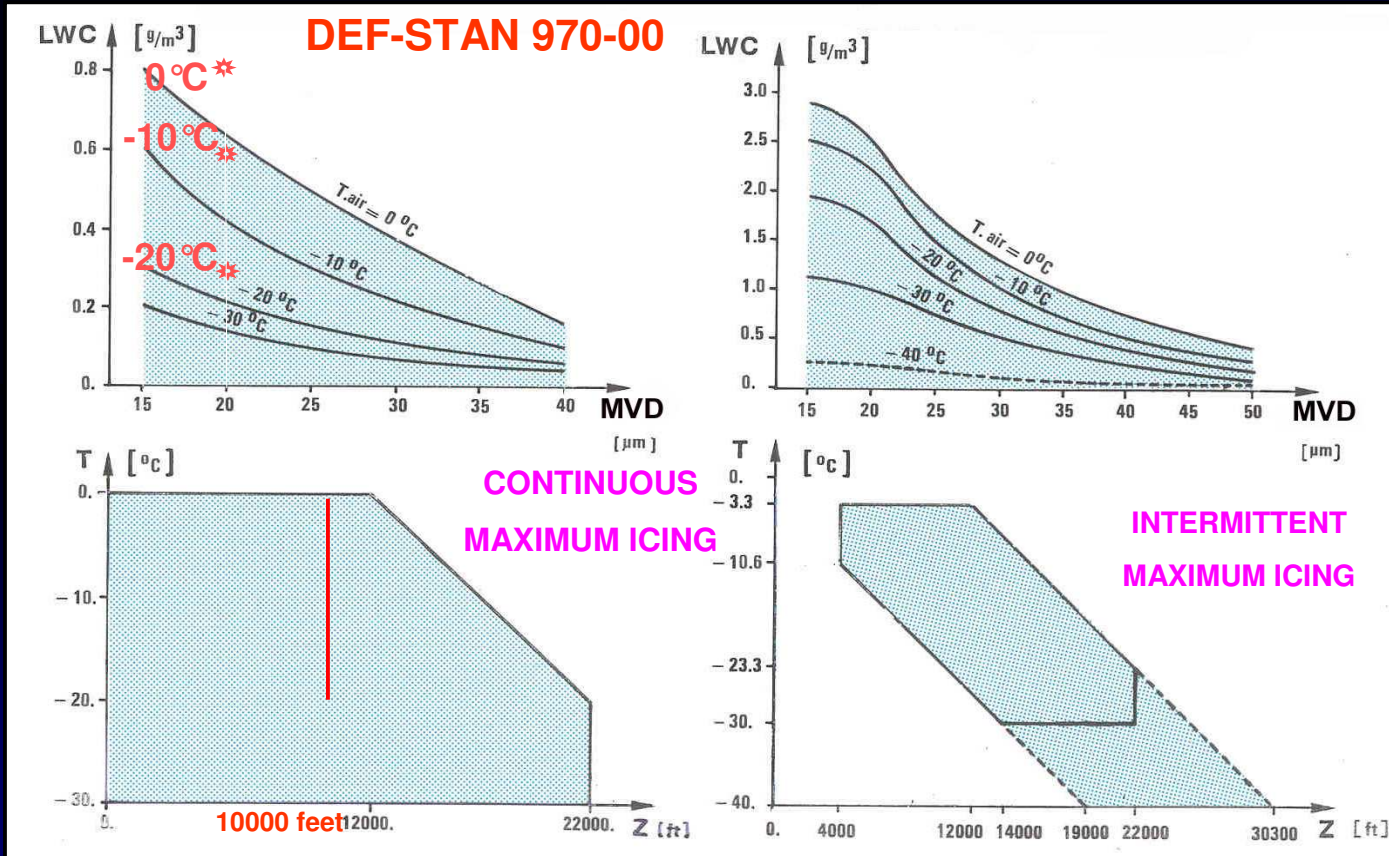


# ICING STANDARDS



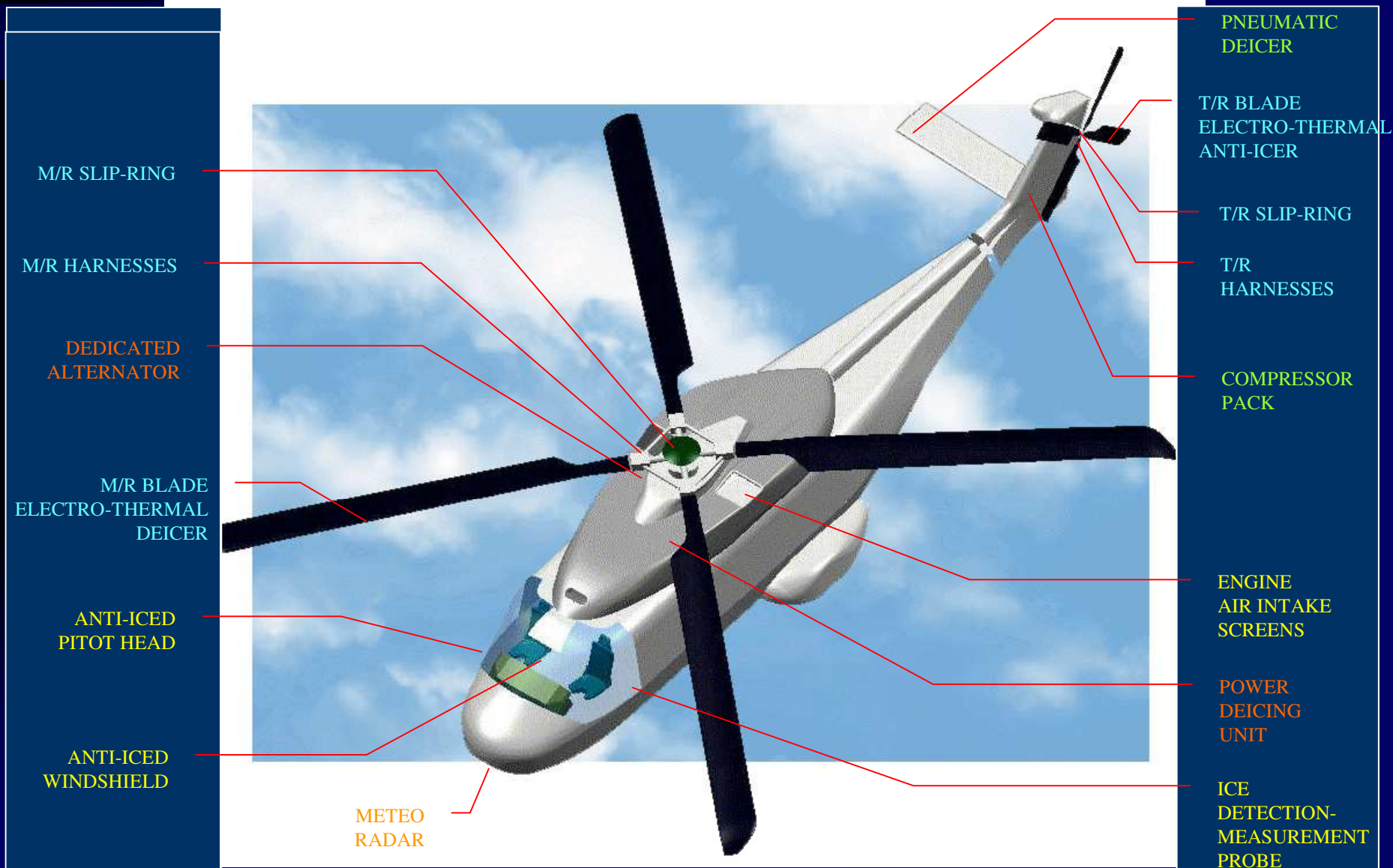
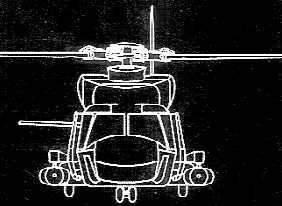
## Claimed envelopes :

- ❑ FAR / JAR 29 Appendix C : NH90 & EC 225 & EC 155
- ❑ and also U.K. DEF-STAN 970 00 : NH90



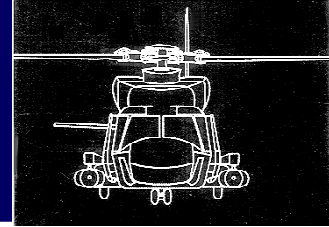


# NH90 : ICE PROTECTION SYSTEM

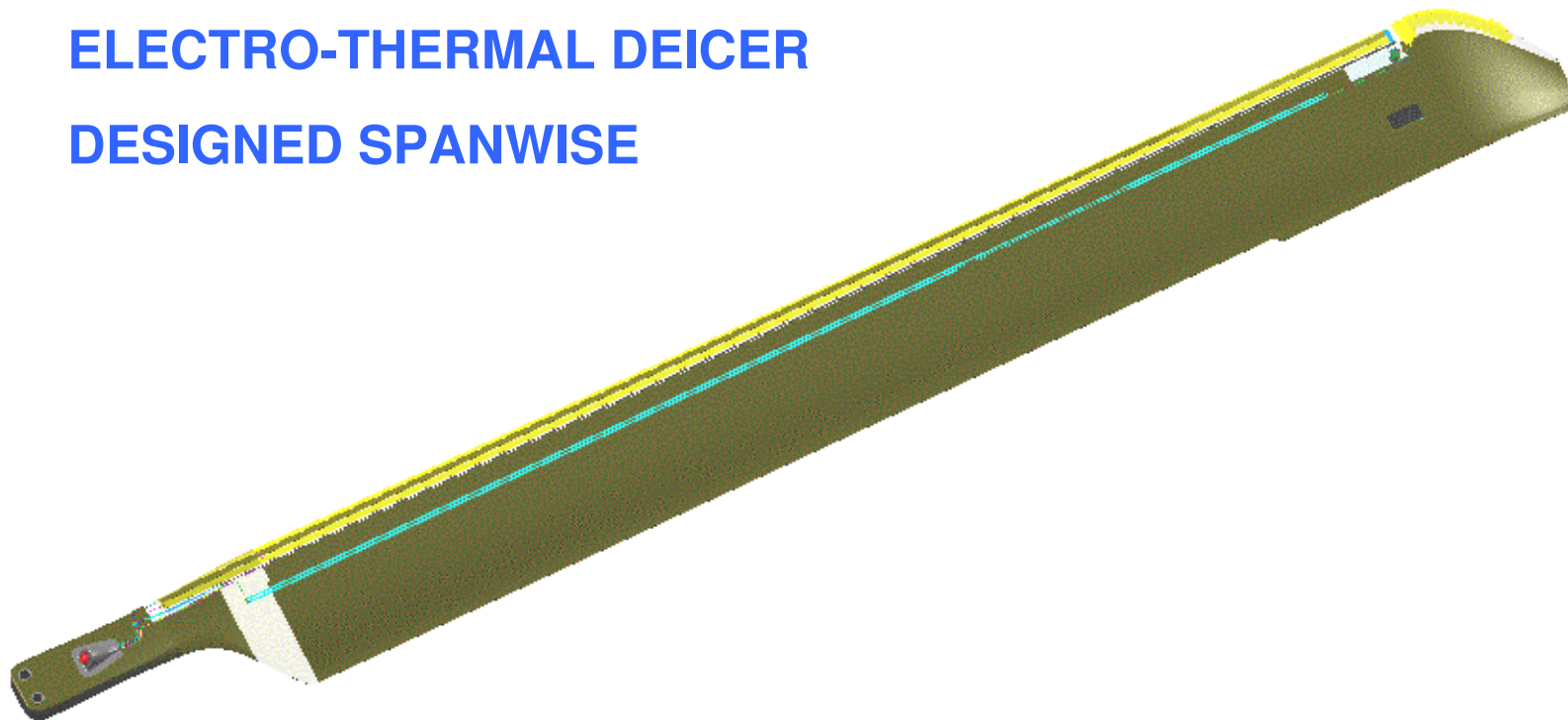




# NH90 - MAIN ROTOR BLADES

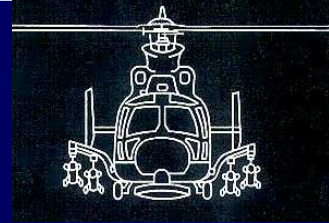


**ELECTRO-THERMAL DEICER  
DESIGNED SPANWISE**



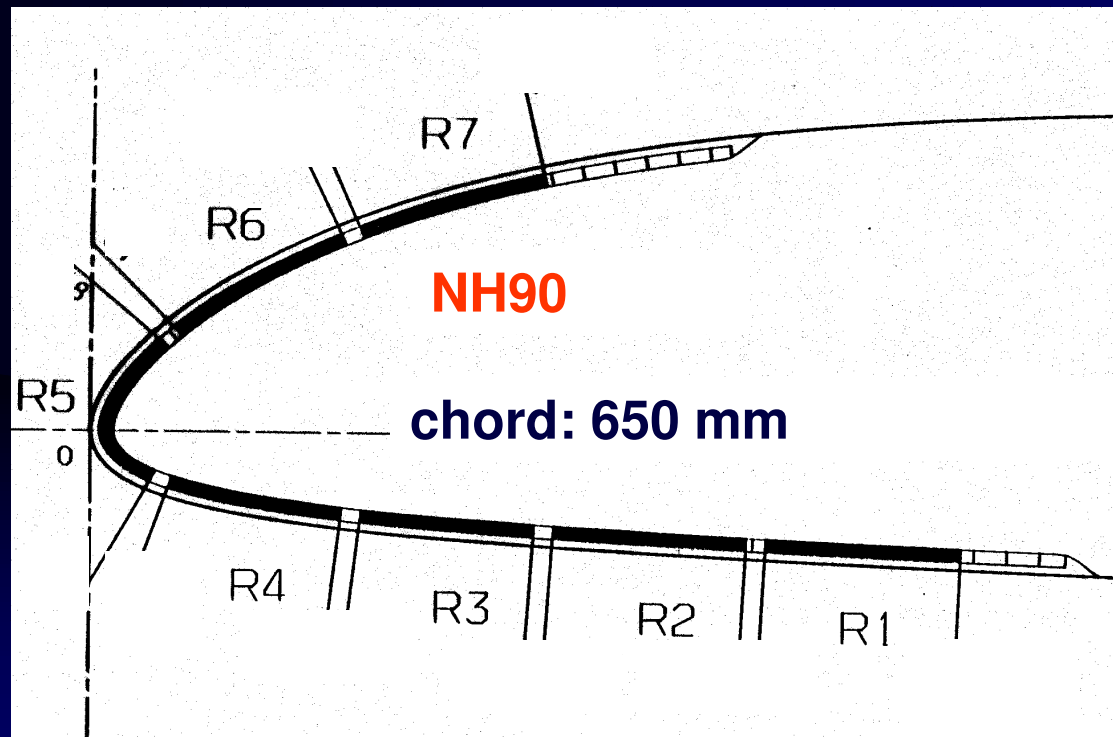


# MRB DEICER : CURRENT SECTION



SPANWISE

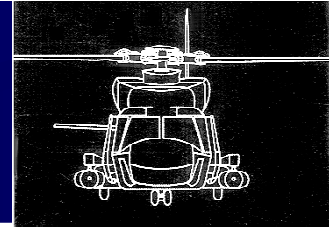
resistors number =  $f(\text{chord})$



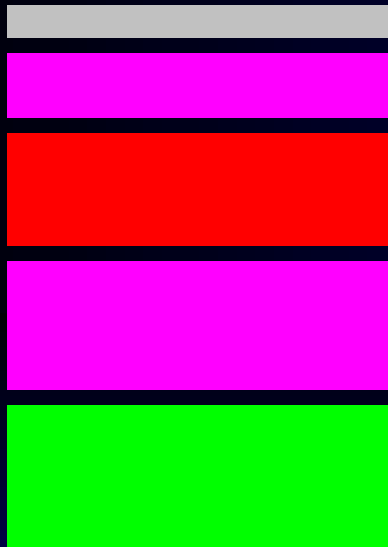




# NH90 - MRB DEICER DESIGN



**RESISTORS = CARBON**



**METALLIC SHIELD**

**GLASS FABRIC**

**RESISTANCE  
(CARBON LAYERS)**

**GLASS FABRICS**

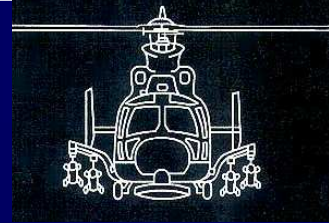
**BLADE (composite)**







# MAIN BLADE - DEICER



✉ **CYCLIC activation of resistors** (automatic)

✉ **ton<sub>(s)</sub> = f ( OAT , resistors )** (automatic)

✉ **MODES :**

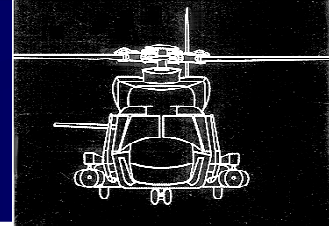
☞ **NORMAL** : automatic after IPS ON by crew

☞ **SEVERE** : if crew action only

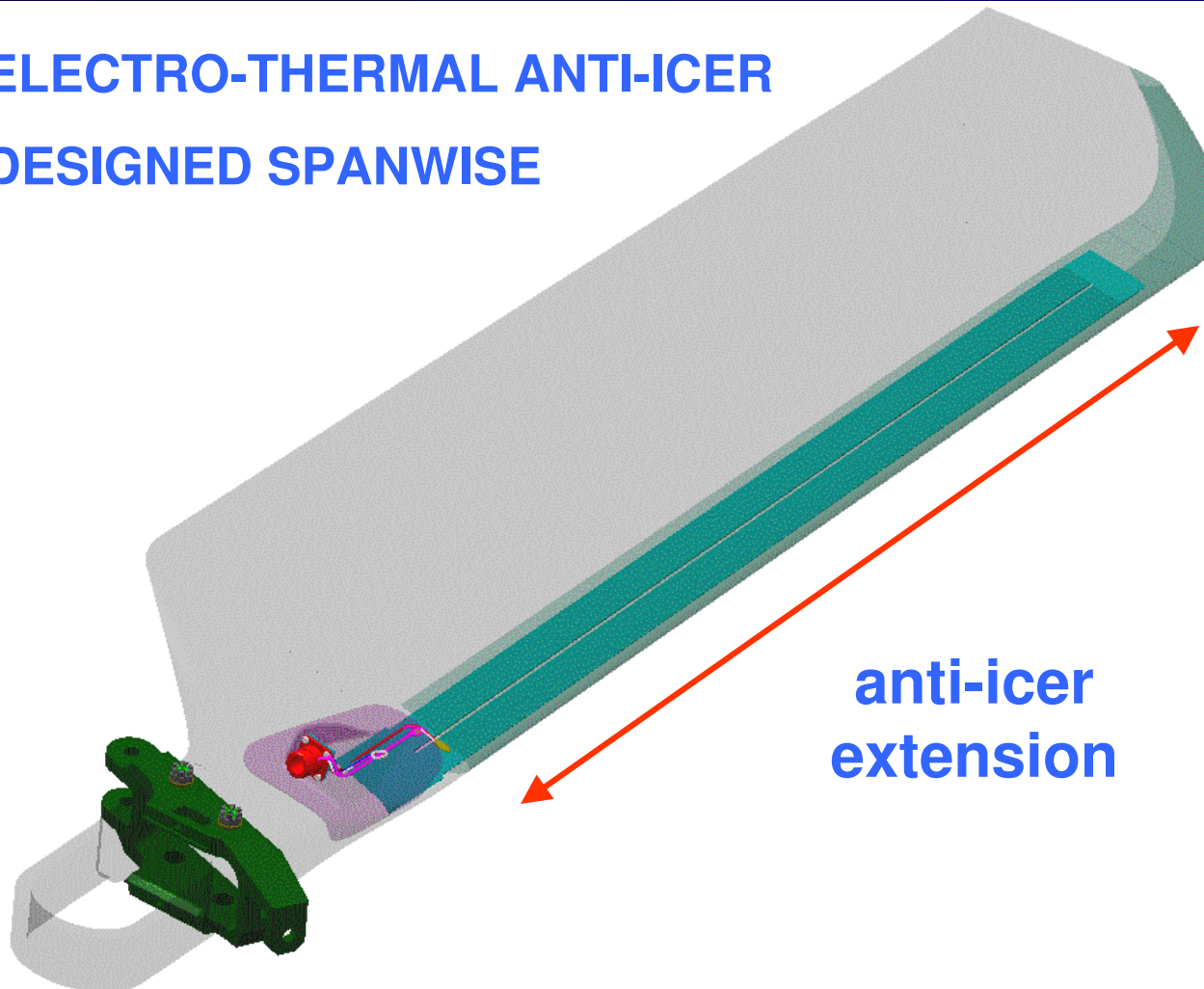
☞ **EMERGENCY** : automatic after loss of part of power



# NH90 - TAIL BLADE - ANTI-ICER



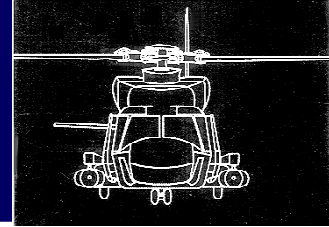
ELECTRO-THERMAL ANTI-ICER  
DESIGNED SPANWISE



anti-icer  
extension



# NH90 - TAIL BLADE - ANTI-ICER

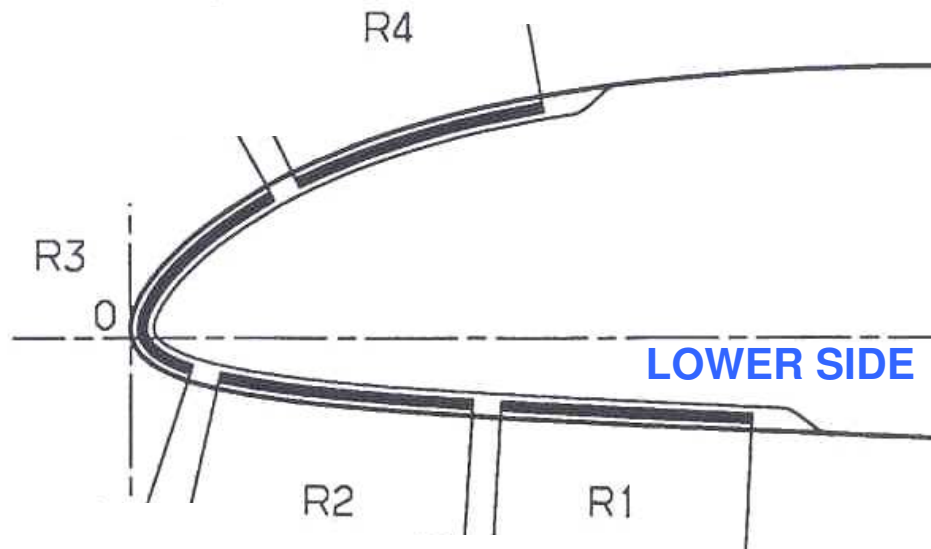


**SPANWISE**

**MATS number = f (chord )**

**Chord: 320 mm**

**UPPER SIDE**



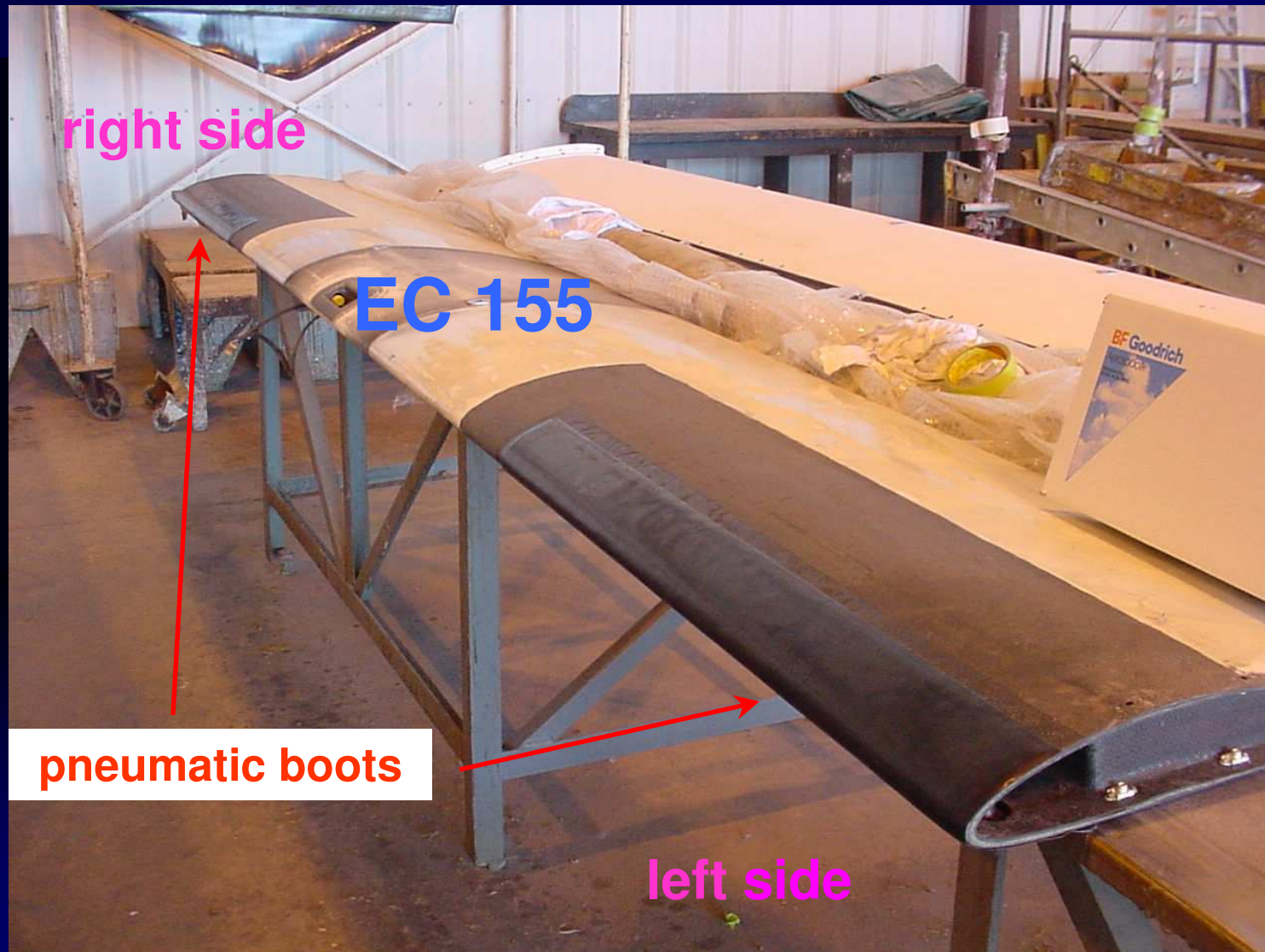
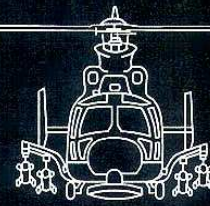
**RESISTORS = CARBON**

	<b>METALLIC SHIELD</b>
	<b>GLASS FABRIC</b>
	<b>RESISTANCE (CARBON LAYERS)</b>
	<b>GLASS FABRICS</b>
	<b>BLADE (composite)</b>

 **SIMULTANEOUS activation of ALL RESISTORS**



# HORIZONTAL STABILIZER ICE PROTECTION SYSTEM





# QUALIFICATION of Ice Protection Sys.:

## general items : goal & means

### domains

### related functions & items

### set of possible means

integration

system integ. & compat.  
blade overheating

flight tests - dry air  
thermal codes (blades)  
wind tunnel - dry air (blades)

IPS efficiency

aero. perfo. of rotors  
engine  
loads  
stresses  
controllability  
stability  
vibrations

deicing/anti-icing code  
wind tunnel - icing  
flight tests - nat. icing

IPS failures

controllability  
stability  
vibrations

wind tunnel - icing  
flight tests - nat. icing  
flight tests - artif. shapes

accretion

inlets/outlets  
sensors (pitots & OAT)  
visibility  
ice shedding

accretion code  
experience  
flight tests - nat. icing





# TESTS in ICING WIND TUNNEL

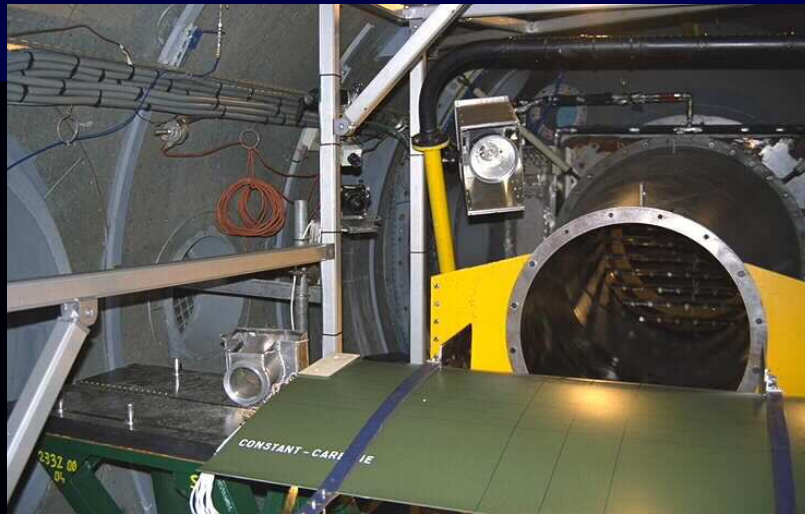
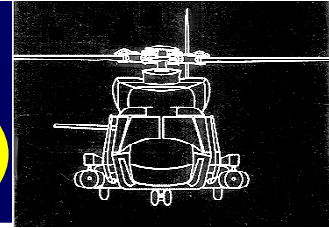


## FULL SCALE TESTS on ITEMS

- **MAIN BLADE (deicer)**  
**MAIN SECTION, EVOLUTIVE PART , TIP**
- **TAIL BLADE (anti-icer)**  
**MAIN SECTION , TIP**
- **STABILIZER & PNEUMATIC BOOT (deicer)**  
**MAIN SECTION**
- **ENGINE AIR INTAKE (anti-icer)**
- **PITOT PROBES (anti-icer)**
- **ICE DETECTOR**



# TESTS in WIND TUNNEL NH90 main blade (main section)



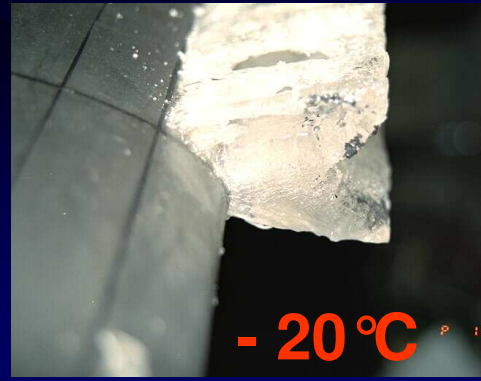
TEST  
SET UP  
(CEPr, Fr.)



ACCRETION



- 30 °C



- 20 °C

DEICING

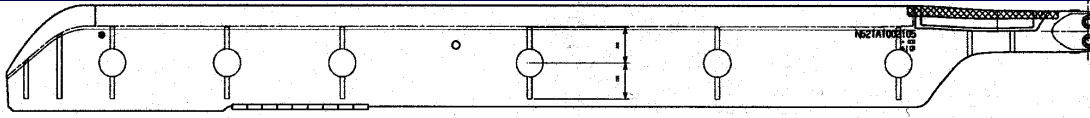
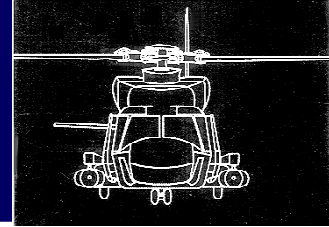


OAT = -20 °C - V = 157 m/s - Z = 1000 m ;

LWC = 0,3 g/m<sup>3</sup> - tc2dc2



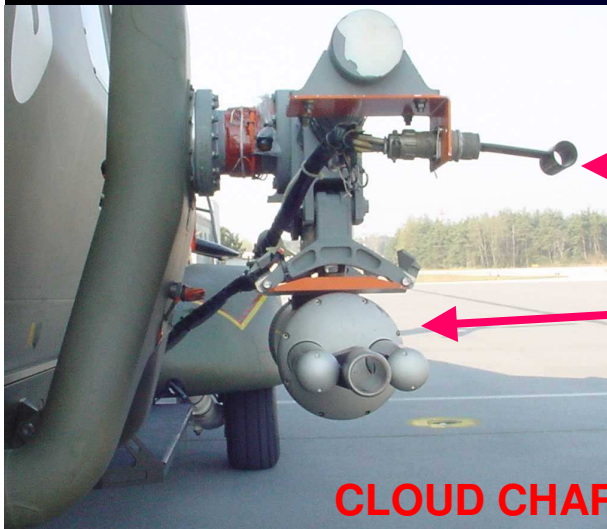
# FLIGHT TEST INSTRUMENTATION



- ❑ THERMAL SENSORS on BLADES
- ❑ MECHANICAL GAUGES
- ❑ MARKS



Several VIDEO CAMERAS



JOHNSON  
WILLIAMS (LWC)

FSSP  
(LWC+MVD)

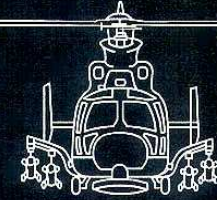
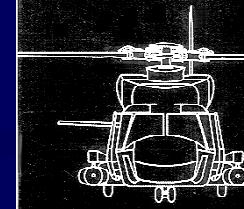
CLOUD CHARACTERISATION



CEV PROBE  
(cumul. th.)



# FLIGHT TEST DRY AIR



## AIMS :

✉ IPS INTEGRATION & FUNCTIONAL TESTS

✉ ADAPTATION of DEICER / ANTI-ICER TIME  
PARAMETERS (PDU soft) :

☐ respect the maximum authorized T°C of materials

✉ OAT SENSORS RESPONSES

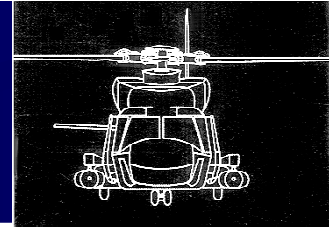
✉ INSTALLATION of COMPLEX FTI for icing (CAMERAS)

⇒ before flights in natural icing conditions

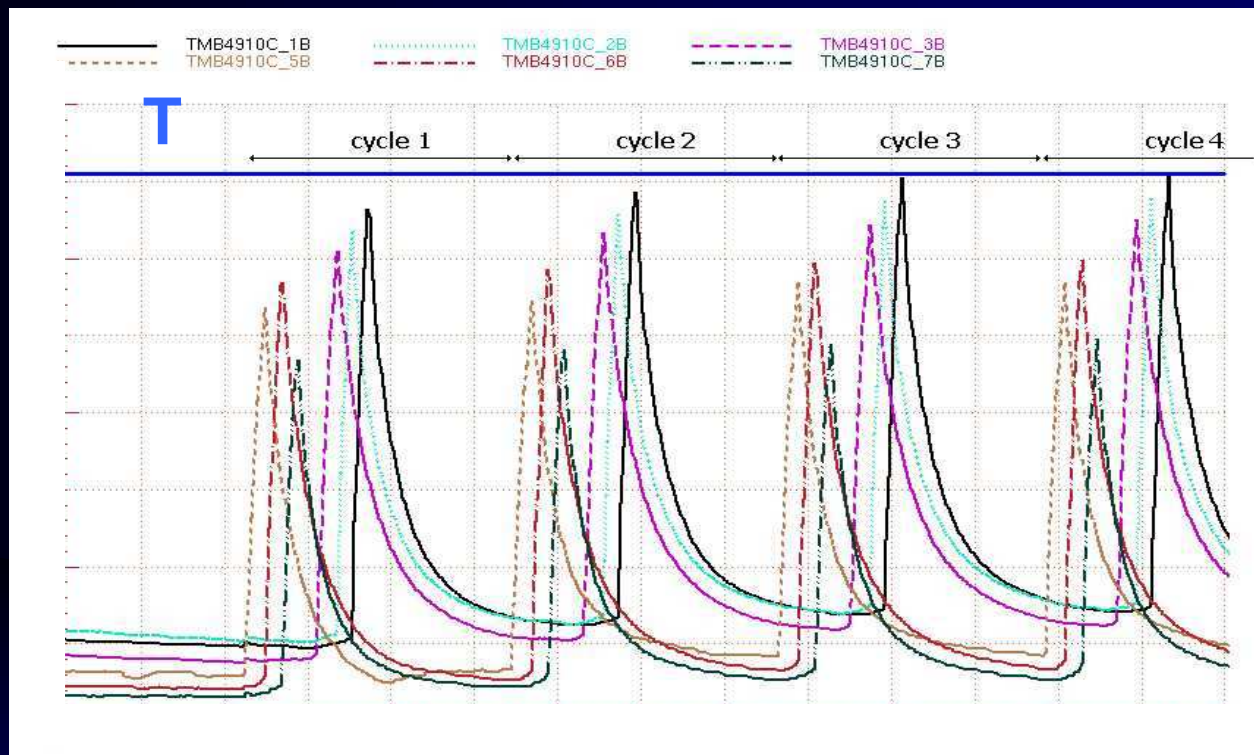




# FLIGHT TEST DRY AIR



## EXAMPLE of BLADE TEMPERATURES



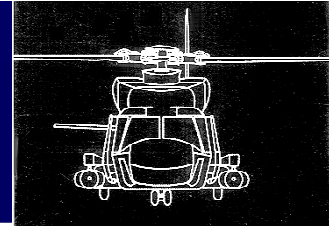
## MAIN BLADE DEICER

**Ex : NH90**





# FLIGHT TEST ICING



## LATERAL PARTS : PROTUBERANT EQUIPMENT



fl182

9 h 46 min 30 s



10 h 07 min

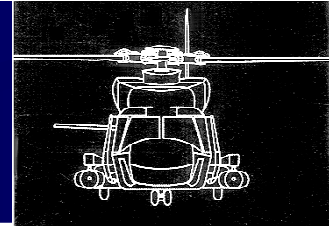
ACCRETION on HOIST

NATURAL SHEDDING when DESCENT

**Ex : NH90**



# FLIGHT TEST ICING



## TAIL PARTS

f1182



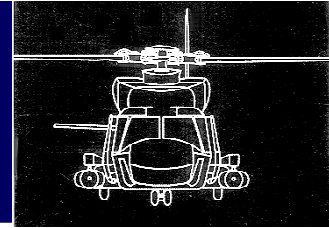
ACCRETION on BLU ANTENNA , TIP of TAIL FIN

NATURAL SHEDDING when DESCENT

**Ex : NH90**



# FLIGHT TEST ICING



Ex : NH90

## MRB DE-ICER EFFICIENCY : 1st example

(1) - before cycle



span extension  
of accretion

(2) - R5



(3) - R5



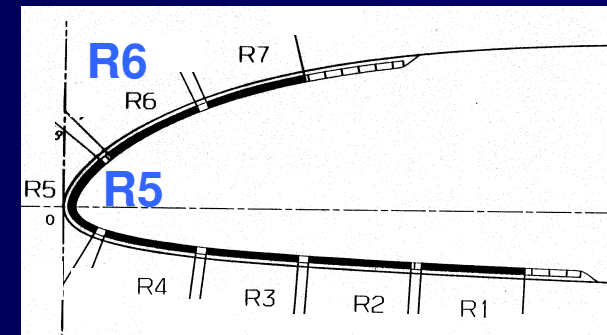
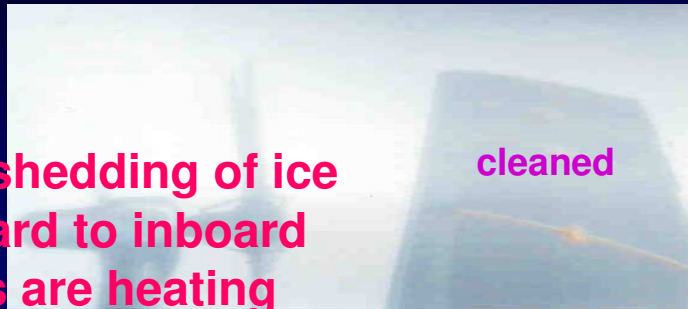
end of  
shedding

(4) - R5



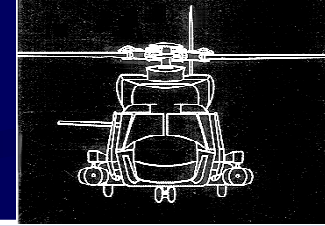
(5) - R6

progressive shedding of ice  
from outboard to inboard  
while mats are heating





# FLIGHT TEST : ICING - results



## After the performed flights and encountered conditions

✉ **GOOD GENERAL R/C BEHAVIOUR in ICING CONDITIONS :**

👉 **MAX ENGINES TORQUE FLUCTUATIONS are not SIGNIFICANT, and are CORRELATED to MR BLADES HEATING CYCLES**

👉 **NO SIGNIFICANT INCREASE of LOADS and VIBRATIONS measured and felt by the crew**

✉ **NEW FLIGHTS in ICING COND. are PLANNED**



# W.G. & RESEARCH ACTIVITIES

## □ participation to working groups :

→ european GARTEUR WG 32 & 33

→ NATO / RTO

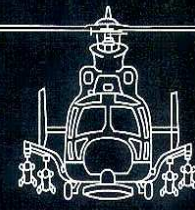
## □ research programmes :

→ « ECLIPPS » project funded by DPAC (MoT, Fr. ) , with ONERA + AIRBUS + DASSAULT :

✉ **goal** = improve validity domain of codes -> increase in qualification process

✉ **scope** = 2D / 3D accretion , 2D deicing / anti-icing, fixed wings & rotor perfo.





***SUPER-PUMA  
Mk1 & Mk2***

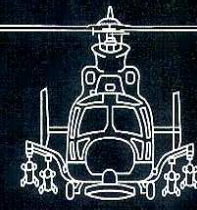
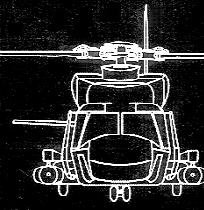
***NH90***

***SUPER-PUMA MK2+  
EC225 / 725***

***EC155***

## **CONCLUSION**

- NEW ICE PROTECTION systems are based on the EXPERIENCE in CERTIFICATION and IN-FLIGHT UTILISATION from SUPER-PUMA MK1**
- introduction of NEW technology for electro-thermal deicer / anti-icer : CARBON RESISTORS**
- certification / qualification of EC155 & EC225 & NH90 -> 2004 to 2005**
- a large data collection for comparisons : codes / tests (wind tunnel & flights)**



***SUPER-PUMA  
Mk1 & Mk2***

***NH90***

***SUPER-PUMA MK2+  
EC225 / 725***

***EC155***

**THE END**

**Thank You**